U.S. Patent Application S.N. 10/644,821
SUBSTITUTE SPECIFICATION
CLEAN COPY

SAMPLING TUBE-TYPE SMOKE DETECTOR

BACKGROUND OF THE INVENTION

The present invention relates to a sampling tube-type smoke detector which suctions air into a sampling tube from a monitored area and optically detects smoke particles floating in the air using a laser beam, and more particularly to a sampling tube-type smoke detector which includes a smoke detection device and an aspirator aligned in a straight line and formed compactly.

Conventionally, a high sensitivity smoke detector which detects slight smoke is used in a clean room, such as a computer room, in a hospital, a semiconductor manufacturing facility and the like. The highly sensitive smoke detector in this invention suctions air from a sampling tube (synonymous with pipe) installed in a monitored area and optically detects the number of particles floating in the air using a laser beam. Thus, a highly sensitive smoke detector with a sampling tube is hereafter designated a sampling tube-type smoke detector. As shown in FIG. **11**, this sampling tube-type smoke detector comprises a sampling tube **101** with suction openings **102** which suctions in air from a monitored area, a smoke detection device **103** which detects smoke particles contained in the suctioned air connected to the sampling tube **101**, and an aspirator **108** which is formed in the downstream of the smoke detection device **103**.

The sampling tube **101** is formed in a monitored area and comprises a detection line **101**a with multiple suction openings **102** every 1-2 meters (1-2m = about 1-2 yards apart) prescribed spacing and a connection line **101b** which guides air to the smoke detection device **103** from the detection line **101**a. Additionally, the smoke detection device **103** connected to the sampling tube **101** is equipped with a laser diode **104**a which is a light emitting device and a photodiode **104**b which is a photo detector. A chamber **107** is formed in the

downstream of the smoke detection device **103** and the aspirator **108** is installed in the interior of the chamber **107**. The smoke detection device **103**, the chamber **107** and the aspirator **108** are dedicated to a detector main body **100** which consists of a cube-type configuration, wall surfaces and the like in formation of the chamber.

The laser diode **104**a generates diffused light extended along the direction of the optical axis which is condensed with an image-formation lens located on the optical axis, and performs image-formation in the flow path of the smoke detection device **103**. Smoke particles are carried to the image-formation position. The light from the laser diode **104**a produces scattered light as a result of these smoke particles. This scattered light is received by the photodiode **104**b located in a position which makes an optical axis of the light from the laser diode **104**a at a predetermined degree angle and generates a pulse signal. A signal processing part **106** detects smoke particles generated by a fire by performing signal processing. Also, air passing through the smoke detection device **103** is discharged in the chamber **107**. Subsequently, this air is discharged outside by the aspirator **108** installed in the chamber **107**.

Such a sampling tube-type smoke detector, for instance, the system in the first conventional example shown in FIG. **12** is used. In this first conventional example, a smoke detection device **103** and an aspirator **108** constitute a sampling tube-type smoke detector, which are placed in a detector main body **100** resembling a cube-type shape. The smoke detection device **103** comprises a lead-in tube **103**a connected with a sampling tube **101**. A smoke sensor unit **104** is located in the intermediate part of the lead-in tube **103**a, detects smoke particles and is arranged in a corner of the detector main body **100**. Additionally, the smoke sensor unit **104** in the downstream of the lead-in tube **103**a is equipped with an airflow sensor **105** for performing clogging detection in the lead-in tube **103**a. The aspirator **108** has a motor-actuated, centrifugal-type fan and discharges air at a predetermined flow rate

to the outside of the detector main body **100**. The aspirator **108** is arranged in a corner of the smoke detection device **103** on the opposite side of the detector main body **100**.

In the case of this first conventional example, segments other than the smoke detection device **103** in the detector main body **100** and the aspirator **108** are hollow and form a chamber **107**. Once air suctioned through a sampling tube **101** passes the smoke detection device **103** and is discharged into the chamber **107**, subsequently the aspirator **108** discharges the air to the outside of the detector main body **100**. With the form of the chamber **107**, the air suction state in the sampling tube **101** can be stabilized by making the pressure inside the chamber **107** low as air is suctioned. Thus, in the first conventional example, since the chamber **107** is formed of the entire detector main body **100**, the signal processing part involving the smoke sensor unit **104**, the power circuit of the aspirator **108**, processing of the detection signal from the smoke sensor unit **104**, and the like are separately located external of the detector main body **100**.

As a sampling tube-type smoke detector, the system in the second conventional example shown in FIG. **13** is used. In this second conventional example, a smoke detection device **103** and an aspirator **108** which constitute the sampling tube-type smoke detector are the same as that of the above first conventional example concerning the point of view of being placed in a detector main body **100** which resembles a cube-type shape. In addition, those which have a smoke sensor unit **104** the same as that of the first conventional example are also used for detection of smoke particles. However, unlike the first conventional example, in the second conventional example, the flow path from a sampling tube **101** to the inlet port of the smoke detection device **103** connected with the aspirator **108** is formed in a single sequence. Specifically, the smoke detection device **103** is a lead-in tube **103**a. The lead-in tube **103**a is located in the intermediate section connected with the sampling tube **101** and

comprises the smoke sensor unit **104** which detects smoke particles. The lead-in tube **103**a of the smoke detection device **103** forms a direct connection to the aspirator **108**. An airflow sensor **105** is formed in the downstream of the smoke sensor unit **104** similar to the first conventional example.

The aspirator **108** is driven by a motor comparable to the first conventional example, has a centrifugal-type fan, and discharges air at a predetermined discharge flow rate to the outside of the smoke detection device **103**. The fan's rotational axis makes an angle of 90 degrees with the upper part of the lead-in tube **103**a. Consequently, the lead-in tube **103**a from the smoke sensor unit **104** bends at an angle of 90 degrees in the downstream part. Thus, without forming a chamber, the inflow of the smoke detection device **103** to the aspirator **108** forms the air duct, and the smoke detection device **103** can be formed compactly. Since in the segment which was the chamber of the detector main body **100** in the first conventional example can be made to create space in the second conventional example, a signal processing part **106** which performs management of smoke particle detection signals and the like from the smoke sensor unit **104** can also be installed in the interior of the detector main body **100**.

However, these conventional sampling tube-type smoke detectors have specific limitations which are described below. The above-mentioned first conventional example suctions air by using the entire detector main body as a chamber and stabilizes the suction state of the sampling tube.

However, to acquire effective stabilization a large-sized chamber is essential. On the other hand, within the constraints of the magnitude of the sampling tube-type smoke detector, target objective stabilization is problematic. Within the chamber, there are existing cases in the interior where a portion of the flow stagnated, which does not necessarily contribute to suction stabilization. Furthermore, in the first conventional example, miniaturization is difficult as most of the main body is used as a chamber. As the signal

processing from the smoke sensor unit, the power circuit and the like are located external of the detector main body, a lot of space is required for the entire device.

Besides, the above-described second conventional example, without a formed chamber the flow path guides the air from the smoke detection device directly to the aspirator and miniaturization is achieved. However, due to a limitation in the bulkiness of the detector main body, the rotational axis of the fan of the aspirator is oriented so that it becomes the lead-in tube of the smoke detection device with an angle of 90 degrees approximately. Therefore, a flow path of 90 degrees must bend. In the section where the flow path bends, pressure loss occurs in the airflow, and a comparatively large-sized fan needs to be used as the aspirator.

This invention introduces a novel approach to solve the above-mentioned limitations, which reduces the airflow pressure loss in the flow path from the smoke detection device to the aspirator, and aims at providing a sampling tube-type smoke detector which has a compact smoke detection device and can be driven by a small-sized fan.

SUMMARY OF THE INVENTION

The present invention has been made in view of the circumstances described above. Accordingly, the purpose of the present invention is to solve the above-mentioned subject. According to the present invention, the sampling tube-type smoke detector comprises a smoke detection device which detects smoke particles contained in the air suctioned through a sampling tube from a monitored area; an aspirator positioned in the downstream of the smoke detection device; the smoke detection device forms a substantially straight line to a lead-in tube which draws suctioned air through the sampling tube; a smoke sensor unit detects smoke particles contained in the air of the lead-in tube; the aspirator forms the actuator mechanism of a rotating part that discharges the

air; and the lead-in tube and the aspirator are oriented with the central axis of the lead-in tube and the rotational axis of the actuator mechanism of the aspirator being substantially the same axis.

According to the present invention, the lead-in tube and the aspirator are arranged so the lead-in tube is formed in a substantially straight line along the central axis of the lead-in tube and the rotational axis of the actuator mechanism of the aspirator are substantially on the same axis. The air duct from the smoke detection device leading to the aspirator can be formed in a substantially straight line and pressure loss in the airflow can be suppressed to a minimum. As the smoke detection device and the aspirator can be formed compactly, the smoke detection device can be miniaturized and driven by a small-sized fan.

According to the present invention, in the sampling tube-type smoke detector the lead-in tube is sequentially connected to the aspirator through an expanded part. The expanded part is formed so that the flow path expands along the traveling direction of the air.

Furthermore, considering the flow path width can be extensively contained as the smoke detection device is formed in sequence with the expanded part to the aspirator, whereby the flow path extends along the traveling direction of the air, airflow pressure loss can be effectively suppressed.

According to the present invention, in the sampling tube-type smoke detector the lead-in tube essentially resembles a substantially round-shaped cross-sectional form. The lead-in tube and the expanded part are connected with the connection part. The connection part inner wall surface connects to the lead-in tube inner wall surface and the expanded part inner wall surface in a reciprocally continuous smooth curved surface.

Further, in this invention, the lead-in tube is effective in suppressing the pressure loss of the airflow by vortex flow generated in the rotating part of the aspirator by being essentially formed in a substantially round shape.

In addition, according to this invention, the lead-in tube is made with a sequentially mutual wall side of the adjacent parts consisting of a segment formed in a substantially square-shape and a segment formed in a substantially round-shape, respectively. In order for the airflow of the lead-in tube to meet in a straight line with the connection part, they are formed together as one piece. As the flow path of the lead-in tube is designed to not produce a level difference, by forming the lead-in tube with the connection part as a mutually sequential smooth curved surface, airflow pressure loss can be suppressed.

According to the present invention, in the sampling tube-type smoke detector, the expanded part inner wall surface which is sequentially formed to the lead-in tube through the connection part resembles a substantially semi-sphere shape. The expanded part is formed in series with the aspirator.

Furthermore, as the expanded part is formed in a substantially semi-sphere shape in the inner wall surface and installed sequentially by the aspirator, it effectively optimizes the abatement of pressure loss in the connection part.

According to the present invention, in the sampling tube-type smoke detector, the connection part is equipped with a thin metal-like aperture. The aperture has an aperture diaphragm opening smaller than the inside diameter of the lead-in tube central part and in the center of the aperture diaphragm opening is arranged substantially on the centerline of the lead-in tube.

According to the present invention, in the sampling tube-type smoke detector, the aperture diaphragm opening of the aperture has a diameter of approximately 30 to 70 percent compared to the inside diameter of the lead-in tube.

Further, in this invention, as the aperture diaphragm opening is a diameter smaller than the inside diameter of the lead-in tube central part and the aperture is fixed so that the center of the aperture diaphragm opening is

arranged to be substantially centerline with the flow path of the lead-in tube, the airflow streaming down the lead-in tube 10 can be controlled as well as decreased air pressure. Also, as the aperture diaphragm opening consists of a diameter approximately 30 to 70 percent in size as compared to the inside diameter of the lead-in tube, the aperture is effectively optimized.

According to the present invention, in the sampling tube-type smoke detector, the aspirator comprises a body part and a discharge part. The body part contains the rotating part and the actuator mechanism. The discharge part discharges air to the outside discharged from the rotating part, and the discharge part is arranged in an approximately vertical direction to the rotational axis of the rotating part. The discharge part discharges the air made to flow in a straight line from the lead-in tube and the expanded part to the side of the aspirator. An air duct for discharging air from the rotating part is arranged in the periphery of the body part. An air discharge vent is formed in the discharge part, and the discharge part is equipped with a guide which forms the air duct and the discharge vent into a reciprocally continuous smooth curved surface.

Further, according to this invention, since a level difference is not produced in the discharge part of the aspirator by having a guide which makes the air duct and the discharge vent into a reciprocally continuous smooth curved surface, air pressure loss can be effectively suppressed.

The above and further objects and novel features of the present invention will more fully appear from the following detailed description when the same is read in conjunction with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevation view showing the internal configuration of the

detector main body in the embodiment of this invention.

FIG. **2** is a right-hand side surface view showing shown the internal configuration of the detector main body in the embodiment of this invention.

FIG. **3** is a front elevation view of the smoke detection device in the embodiment of this invention, the connection part and an aspirator.

FIG. **4** is cross-sectional view of the lead-in tube in the embodiment of this invention and a connection part.

FIG. **5** is a bottom view of the lead-in tube in the embodiment of this invention and a connection part.

FIG. **6** is cross-sectional view of the lead-in tube in the embodiment of this invention.

FIG. **7** is a schematic diagram of the sampling tube in the embodiment of this invention.

FIG. **8** is a cross-sectional drawing showing the assembly and sequential formation of the lead-in tube and the aspirator in the embodiment of this invention.

FIG. **9** is a side view which shows the aspirator from the lead-in tube side in the embodiment of this invention.

FIG. **10** is a mimetic diagram showing the principle of detection of smoke particles in the smoke sensor unit.

FIG. **11** is a mimetic diagram showing the outline of a prior art sampling tube-type smoke detector.

FIG. **12** is a mimetic diagram showing the first conventional prior art example.

FIG. **13** is a mimetic diagram showing the second conventional prior art example.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will hereinafter be described in detail with reference to the preferred embodiment shown in the accompanying drawings. FIG. **1** is a front elevation view showing the internal configuration of the detector main body in this embodiment. FIG. **2** is a right-hand side surface view of FIG. **1**. FIG. **3** is a front elevation view of the smoke detection device in this embodiment. FIG. **4** is cross-sectional view of the lead-in tube which constitutes the smoke detection device and the inter-connection part.

The sampling tube-type smoke detector in this embodiment comprises a sampling tube **3** with suction openings **42** (see Fig. **7**) formed in a monitored area. A smoke detection device **1** detects smoke particles contained in the air suctioned through the sampling tube **3.** An aspirator **2** is formed in the downstream of the smoke detection device **1.** The smoke detection device **1** and the aspirator **2** connect by way of an inter-connection part **15**. Among those which constitute the sampling tube-type smoke detector, the smoke detection device **1**, the aspirator **2**, and the inter-connection part **15** are placed in a detector main body **20**, which consists of a cube-type configuration as shown in FIG. **1**. In addition, the smoke detection device **1** is connected with the sampling tube **3**. The air drawn from the sampling tube **3** through the smoke detection device **1** is discharged outside from the aspirator **2**. This air duct, from an inflow **11** of the smoke detection device **1** until ending at the inflow point of the aspirator **2** without bending, forms a substantially straight line shape and decreased pressure by way of pressure loss is suppressed.

The smoke detection device **1** and the aspirator **2** are arranged in a corner of the detector main body **20**. The remaining section consists of a hollow interior formed with a control apparatus **21** and a power supply **22**. Furthermore, in the interior of the detector main body formed by the smoke detection part **1**, the inter-connection part **15** and the aspirator **2**, air from the monitored area does not flow into a section other than an air duct **36** (Fig. **8**) of the aspirator.

As shown in FIG. **7**, the sampling tube **3** is composed of a T-shaped line formed in the monitored area and has a detection line **40** with two or more suction openings **42**. The detection line **40** is formed at a perpendicular with a connection line **41** connected to the smoke detection device **1**. As for the detection line **40** and the connection line **41**, both resemble a substantially round- shaped cross-sectional form. The detection line **40** suction openings **42** are located every 1-2 meters (1-2m = about 1-2 yards apart) prescribed spacing and formed in a standard round shape of 1-2 millimeters (1-2mm = about 0.04-0.08 inches) in diameter. The connection line **41** is formed in a substantially straight line shape and connected to a lead-in tube **10** of the smoke detection device **1** in a substantially straight line. Thus, the centerline of the connection line **41** is approximately in a direct line with the centerline of the lead-in tube **10** and oriented to substantially coincide.

As shown in FIGS. **3** and **4**, the smoke detection device **1** is equipped with a smoke sensor unit **4** which detects smoke particles in the lead-in tube **10** formed in a substantially straight line from the air inflow **11** connected to the sampling tube **3** to an air outflow **12**. Additionally, the smoke detection device **1** consists of a Light-Emitting Diode **5** (hereafter referred to as LED **5**) for performing sensitivity tests of the smoke sensor unit **4** and an airflow sensor **6** which measures the flow velocity. Thus, the lead-in tube **10** of the smoke detection device **1** is formed in a substantially straight line, without bending the air duct from the inflow **11** until reaching the outflow **12**. Therefore, since the centerline constitutes a substantially direct line, the connection line **41** of the sampling tube **3** and the inflow **11** of the lead-in tube **10** until reaching the outflow **12** is formed sequentially on a substantially straight line.

The lead-in tube **10** essentially resembles a substantially round-shaped cross-sectional form entirely. However, the segment around the inflow **11** of the lead-in tube **10** resembles a substantially square-shaped cross-sectional form where the four corners are beveled. In this substantially square-shaped section,

the smoke sensor unit **4** and the airflow sensor **6** are attached sequentially from the upper part and form a stationary portion **14**. FIG. **6** shows the lead-in tube **10** the part formed in a substantially square-shaped cross-sectional segment in which the smoke sensor unit **4** is attached. The lead-in tube **10** is then formed in a substantially round-shaped cross-sectional segment in the downstream portion from the mounting locations of the adjacent inflow **11** and the airflow sensor **6**. The downstream part of the lead-in tube **10** (i.e., the cross-sectional segment near the aspirator **2**), is also formed in a substantially round shape. This has an effect on the airflow produced in the rotary motion of a rotating part **32** of the aspirator **2**, which is suppressed at a low level and pressure loss is reduced as much as possible.

In this way, because the sectional form changes along the way, the lead-in tube **10** causes a level difference in adjacent parts **18**a and **18**b of the substantially square-shaped cross-sectional segment and the substantially round-shaped cross-sectional segment, respectively. Except these adjacent parts **18**a and **18**b form a smooth curved surface of the substantially square-shaped cross-sectional segment and the substantially round-shaped cross-sectional segment to respectively continue sequentially. Consequently, the fact that the adjacent parts **18**a and **18**b are formed so that the different cross-sectional form segments continue in series, they do not cause airflow turbulence and air pressure loss in the lead-in tube **10** is suppressed at a low level.

The smoke sensor unit **4** for detecting smoke particles which flow inside the lead-in tube **10** of the smoke detection device **1** segment resembles a substantially rectangle-shaped cross-sectional form. The smoke sensor unit **4** is formed in the upper part of the segment resembling a substantially square-shaped cross-sectional form, (i.e., the stationary portion **14** near the inflow **11** of the lead-in tube **10**). Since the smoke sensor unit **4** is formed in a location distant from the aspirator **2**, this lessens the effects of vortex flow (spiral

motion) and the like on the smoke sensor unit **4** from the aspirator **2** formed in the downstream of the lead-in tube **10**.

As shown in FIG. **10** as a mimetic diagram of the detection principle of the smoke particles, the smoke sensor unit **4** is equipped with a laser diode **60** which emits a laser beam and a photodiode **61** which receives the laser beam. The laser diode **60** is equipped with a laser diode tip **60**a, whereby an electric field creates a diffusion (spreading) wave of the laser beam into a single polarization oscillation which is constant in a predetermined direction and performs output radiation. The laser beam from the laser diode **60,** which performs the output radiation, is condensed with an image-formation lens **62**. The image-formation lens **62** is oriented so that image-formation of the laser beam may be performed on the centerline of the lead-in tube **10** of the smoke detection device **1** where the air current passes. Furthermore, the photodiode **61** is arranged on a light detecting optical axis **65** parallel to the direction of an electric field **E**. An ellipse pattern **67** shows the optical intensity distribution direction of a laser beam optical axis **64** cross-sectional, which passes and diffuses an image-formation position **63** by arrow **66**.

The air current which flows inside of the lead-in tube **10** of the smoke detection device **1** passes through the image-formation position **63** of the laser beam from the laser diode **60** as mentioned above. The image-formation of the light source image from the laser diode **60** is projected onto the laser beam image-formation position **63**. This image constitutes a microscopic spot of about 1 μm (one thousandth (10^{-3}) of a millimeter). For this reason, a smoke particle contained in the air current passes the spot segment of the image-formation position **63** one by one. If smoke particles pass the spot segment of the image-formation position **63**, scattered light occurs. This scattered light will be most efficiently received by the photodiode **61** oriented parallel and toward the direction of the laser beam electric field **E**, and the light detecting pulse signal will be acquired.

Signal processing of the light detecting pulse signal of the smoke sensor unit **4** is sent and processed by a signal processing part **23**, which judges the existence of smoke particles. In the signal processing part **23**, for example, by counting the number of times the light detecting pulse signal unit of time exceeds the predetermined threshold, the microscopic smoke density is calculated based on this number of counts. Also, smoke density can be calculated based on the total value of the pulse width of the light detecting pulse signal obtained in relation with the unit of time. On occasions when the predetermined smoke density is calculated in the signal processing part **23**, an alarm signal is generated, the predetermined LED of an LED area **24** located in the control apparatus **21** lights up, and the signal processing part **23** reports an outbreak of a fire.

Additionally, the LED **5** for testing is formed in a position which adjoins the smoke sensor unit **4** in the lead-in tube **10**. LED **5** for testing is oriented on the optical axis of the photodiode **61** which is the photo detector of the smoke sensor unit **4**. Also, LED **5** performs incidence of the examined pulsed light corresponding to the scattered light at the time smoke particles pass through the image-formation position **63** to the photodiode **61**. If needed for reference the number of passing smoke particles per unit of time in contrast to smoke density beforehand, light emission from LED **5** for testing can be accomplished easily in a sensitivity test corresponding to an arbitrary smoke density.

In the segment resembling a substantially square-shaped cross-sectional form of the lead-in tube **10**, the airflow sensor **6** is formed in the downstream part of the smoke sensor unit **4**. As the airflow sensor **6** as well as the smoke sensor unit **4** is attached to the stationary portion **14** located in the upper part of the lead-in tube **10**, it is hardly vortex flow and the like influenced from the rotating part **32** of the aspirator **2**. A thermal type element with a thermistor component is used for the airflow sensor **6** and formed without protruding into the flow path of the lead-in tube **10**. In this manner, without disrupting the

airflow, pressure loss is prevented.

A filter which is not illustrated is located in the sampling tube **3**. Dust and the like from a monitored area suctioned from the sampling tube **3** are prevented from entering into the smoke detection device **1**. In the event this filter is blocked from dust and the like in, the discharge of air deteriorates and the system becomes incapable of detecting smoke particles in the smoke detection device **1**. For this reason, the airflow sensor **6** measures the flow velocity in the smoke detection device **1**. On occasions when the speed decreases below a constant value with the flow velocity, the airflow sensor **6** generates an alarm signal. An alarm signal is sent to the control apparatus **21**, and generates an alarm report for a clogged filter by making the predetermined LED of the LED area **24** switch on (light up).

As shown in FIGS. **8** and **9**, the aspirator **2** constitutes a discharge part **31** in the body part **30** equipped with the rotating part **32** and an actuator mechanism **33**. The body part **30** forms the rotating part **32** and the actuator mechanism **33** in the center. The air duct **36** is located spaced between a periphery line **35** of the rotating part **32** and the body part **30**. Also, the contour of the body part **30** is formed in a substantially cylinder shape so that the air duct **36** located in the periphery to the rotating part **32** constitutes a substantially constant width.

As shown in FIG. **8**, the rotating part **32** holds the centrifugal fan blades **32**a. The centrifugal fan blades **32**a feed air to the periphery from the central part in a rotary motion. The centrifugal fan blades **32**a are formed by a turntable **32**b, which connects the actuator mechanism **33** with the centrifugal fan blades **32**a. The periphery line **35** of the centrifugal fan blades **32**a constitute a substantially round shape, where between the periphery line **35** of the centrifugal fan blades **32**a and the body part **30** forms the air duct **36**. The actuator mechanism **33** comprises a motor and is connected with the turntable **32b** of the rotating part **32**. For this reason, the rotating part **32** and the actuator

mechanism **33** are constituted considering a rotational axis **34** as the same axle.

A sectional drawing of the aspirator **2** as seen from the direction of the lead-in tube **10** is shown in FIG. **9**. When the actuator mechanism **33** rotates counter clockwise, the centrifugal fan blades **32**a also rotate in the counter clockwise direction, draw the air of the lead-in tube **10**, and discharge this air in the direction of the outer side of the centrifugal fan blades **32**a to the air duct **36**. Air discharged by the air duct **36** flows along the periphery inner wall surface of the body part **30,** and subsequently discharged from the discharge part **31** to the outside of the body part **30**.

Additionally, it is advisable to install a cap **37** in the discharge part **31** according to the circumstances of the physical relationship of the discharge part **31** located in the detector main body **20**. More specifically, when a discharge vent **31**a is placed closer to the center rather than the periphery of the aspirator **2**, in this position it causes a level difference in the periphery of the air duct **36** and the discharge vent **31**a in the body part **30**. Therefore, in order to smooth the flow path applied to the discharge vent **31**a from the periphery of the air duct **36** in the body part **30**, attach the cap **37** in the aspirator **2**. The cap **37** constitutes the segment used as the discharge vent **31**a, and the segment for attaching in the aspirator **2**. The discharge vent **31**a resembles a substantially round-shaped cross-sectional form, and it is arranged at the center closer to the periphery part of the aspirator **2** when the cap **37** is attached in the aspirator **2**. A guide **37**a is formed in the cap **37**. The guide **37**a is applied to the discharge vent **31**a from the air duct **36** located in the periphery of the body part **30**, and constitutes to connect the flow path into a smooth curve transition surface. In this way, by forming the air duct **36** in the discharge part **31** of the aspirator **2** into a smooth curve, the air pressure loss produced by a level difference can be reduced, and the discharge vent **31**a can be arranged in the desired position of the detector main body **20**.

In addition, as shown in FIG. **8**, the rotating part **32** of the aspirator **2** is constituted as having the actuator mechanism **33**, which projects to the central part in the lead-in tube **10** side. If the lead-in tube **10** were to be connected directly with the aspirator **2**, between the actuator mechanism **33** and the lead-in tube **10**, it will become very narrow. Thus, when constructed, the air duct will narrow in the connection segments of the lead-in tube **10** and the aspirator **2**, and will produce airflow pressure loss in the segment. For this reason, between the lead-in tube **10** and the aspirator **2**, an inter-connection part **15** which is explained below is provided.

As shown in FIG. **4**, the inter-connection part **15** has an expanded part **17** where the flow path expands along the direction of air movement, and connects the lead-in tube **10** of the smoke detection device **1** to the expanded part **17** by a connection part **16**. The expanded part **17** resembles a substantially semi-sphere shape in the inner wall surface. The connection part **16** makes the lead-in tube **10** and the expanded part **17**, which are formed in a substantially straight line, progress along a smooth curve. The expanded part **17** formed in a substantially semi-sphere shape in the inner wall surface is arranged substantially on the centerline of the lead-in tube **10**. The air flows down a straight line flow path in lead-in tube **10**, and also without bending in the inter-connection part **15**, which is made to flow down to the aspirator **2**.

The inter-connection part **15** can be connected to the smoke detection device **1** and the aspirator **2** without narrowing the flow path from the lead-in tube **10** to the aspirator **2**. This is achieved by having the expanded part **17**, which forms the inner wall surface in a substantially semi-sphere shape. Concerning the contour of the expanded part **17**, besides the substantially semi-sphere shape, connecting a cylindrical element which has a larger inside diameter compared with the lead-in tube **10** or an element formed in a substantially cone shape and a substantially trumpet shape have been considered. However, in this invention, the element formed in an a

substantially semi-sphere shape is the most preferred.

In addition, the lead-in tube **10** and the inter-connection part **15** are formed in one cylindrical body. Therefore, the lead-in tube **10**, the connection part **16**, and the expanded part **17** are formed as a series of flow paths. Further, this series of flow paths from the lead-in tube **10** to the inter-connection part **15** are shapes which eliminate surface irregularities as much as possible.

Thus, the flow path from the lead-in tube **10** until the inter-connection part **15** is formed as a continuous smooth contour without surface irregularities. Pressure loss by vortex flow or the like caused irregularities and pressure loss by friction produced from irregularities in the surface flow path can be reduced. Thus, as the lead-in tube **10** and the inter-connection part **15** are formed in one piece, air can be efficiently suctioned with the aspirator **2** without creating crevices (gaps) in the flow path. The lead-in tube **10** and the inter-connection part **15** are comprised of ABS resin (thermo plastic) and the like resin material, and cast in one piece using a molding die.

As shown in FIGS. **4** and **5**, an aperture **50** with an aperture diaphragm opening **51** is formed in the central part of the connection part **16**. The aperture **50** is made of round thin metal. The aperture diaphragm opening **51** is a diameter smaller than the inside diameter of the lead-in tube **10** central part. The aperture diaphragm opening **51** consists of a diameter approximately 30 to 70 percent in size as compared to the inside diameter of the lead-in tube **10**. Additionally, the aperture **50** is fixed so that the center of the aperture diaphragm opening **51** is arranged to be substantially centerline with the flow path of the lead-in tube **10** and the inter-connection part **15**.

Airflow travels down the lead-in tube **10** and comprises low flow velocity near the wall surface boundary layer and high flow velocity near the centerline mainstream section. By forming the aperture **50** in the inlet port of the inter-connection part **15**, of the airflow which streams down the lead-in tube **10**, only the flow of the mainstream section can be guided to the inter-connection part

15 or the aspirator **2**, and the decreased air pressure can be controlled. Additionally, the effect of the airflow turbulence accompanying the rotation of the rotating part **32** of the aspirator **2** has on the smoke sensor unit **4** or the airflow sensor **6** can be reduced by the aperture diaphragm opening **51** of the aperture **50**.

A connection flange **19** is formed in a connection opening **13** which is the vent for the inter-connection part **15**. The connection flange **19** and the aspirator **2** are connected with screws. In this case, as shown in FIG. **8**, the aspirator **2** is installed in the smoke detection device **1** so the flow path of the lead-in tube **10** may be countered. Thus, the rotating part **32** of the aspirator **2** and the rotational axis **34** of the actuator mechanism **33** are arranged in a straight line and formed to be substantially centerline of the lead-in tube **10**. Thereby, from the lead-in tube **10** to the inflow of the inter-connection part **15** and the aspirator **2**, the flow path is formed in a substantially direct line.

Thus, by forming an air duct in the detector main body **20** in a substantially direct line, air pressure loss in the smoke detection device **1** or the inter-connection part **15** can be suppressed to the minimum. Although the aspirator **2** constitutes a centrifugal fan that is smaller-sized than before, a predetermined airflow rate can be achieved. Therefore, the smoke detection device **1**, the aspirator **2**, and the inter-connection part **15** in the detector main body **20** can be formed compactly. As a larger space can be secured in the detector main body **20** compared to conventional sampling tube-type smoke detectors, the control apparatus **21**, the power supply **22** and the like can be made built-in the detector main body **20** and miniaturization of the entire device can be attained.

The power supply **22** supplies the control apparatus **21** and power source which processes the signal from the smoke sensor unit **4** and generates an alarm are formed in space other than–the smoke detection device **1** of a detector main body **20**, the aspirator **2** and the inter-connection part **15**. The

control apparatus **21** contains the signal processing part **23**. The signal processing part **23** receives the light detecting pulse signal from the light detecting part of the smoke sensor unit **4** and detects the existence of smoke particles. If the smoke density exceeds a constant value, LED of the LED area **24** located in the control apparatus **21** will light up and an outbreak of a fire will be reported. Equipped with multiple LEDs, separate LED can be made to emit light according to the smoke density.

In addition, the signal processing part **23** receives signals from the airflow sensor **6** formed in the smoke detection device **1**. LEDs different from those which report an outbreak of a fire in the LED area **24** located in the control apparatus **21** emit light (light up) on occasions when the flow velocity in the flow path of the lead-in tube **10** becomes less than a constant value and for a clogged line. Also, the power supply **22** comprises an AC power supply input, a power switch and a conversion circuit that changes alternating current into direct current. The power supply **22** is formed on the same substrate as the control apparatus **21** and supplies the power source to the smoke sensor unit **4**, the airflow sensor **6** and the control apparatus **21**.

Although only one embodiment of this invention was explained until now, this invention should not be limited to the embodiment described above, but may be realized in forms which are variously different within the limits of the technological concept. For example, in this embodiment, in regard to the lead-in tube **10** and the inter-connection part **15** being formed in one piece, by remaking these as separate elements, respectively, they also may well be oriented on the centerline of the expanded part **17** and substantially centerline of the lead-in tube **10**. In this embodiment, the aperture **50** was formed in the inlet port of the inter-connection part **15**. However, even if the aperture **50** is not necessarily provided, should the lead-in tube **10**, the inter-connection part **15** and the aspirator **2** be arranged in a straight line, reduction of the air pressure loss can be promoted.

In this embodiment, although the control apparatus **21** and the power supply **22** are dedicated to the interior of the detector main body **20**, these can also be located external of the detector main body **20** as separate element. Furthermore, the detection method of the smoke density by the control apparatus **21** can use all the methods recognized conventionally which detect scattered light by smoke particles. Moreover, in this embodiment, as opposed to making an LED of the LED area **24** located in the control apparatus **21** light up when the control apparatus **21** detects smoke particles, the control apparatus **21** can also transmit an alarm signal via an external disaster prevention receiving panel and the like over communication lines.

While the present invention has been described with reference to the preferred embodiments, it is our intention that the invention be not limited by any of the details of the description thereof.

As this invention may be embodied in several forms without departing from the spirit of the essential characteristics thereof, the present embodiments are therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within meets and bounds of the claims, or equivalence of such meets and bounds thereof are intended to be embraced by the claims.